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Canada/Northwest Territories Conservation and Renewable Energy Demonstration Program

Energy, Mines and Resources Canada

Energie, Mines et Ressources Canada

Northwest Territories Public Works

ARENA ICE PLANT
WASTE HEAT
RECOVERY

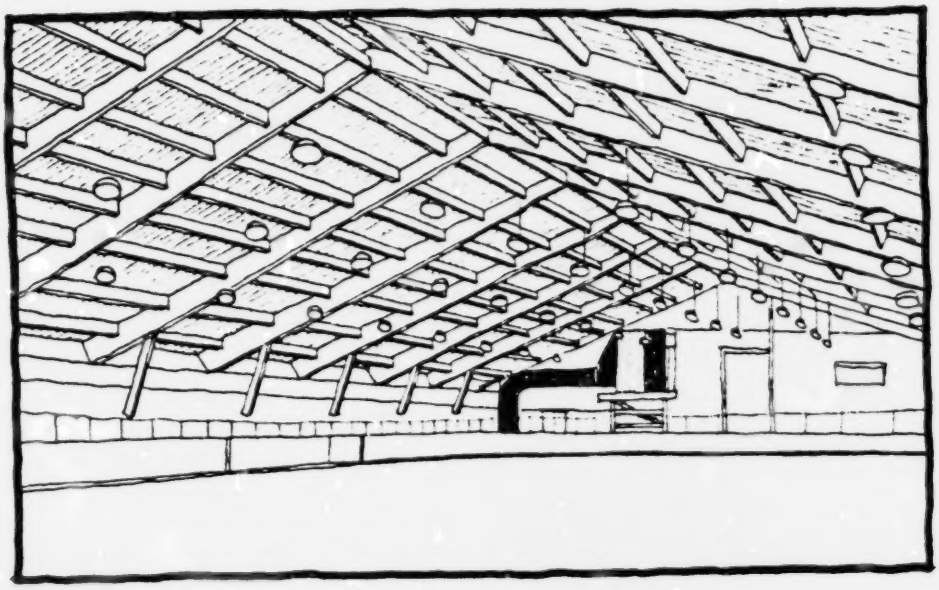
Prepared By

FERGUSON , SIMEK , CLARK LTD

PINE POINT ARENA ICE PLANT

HEAT RECOVERY RETROFIT PROJECT

ENERGY, MINES AND RESOURCES CANADA
&
ENERGY CONSERVATION DIVISION
DEPARTMENT OF GOVERNMENT SERVICES
GOVERMENT OF THE NORTHWEST TERRITORIES



THIS PROJECT WAS CONVENED BY
CANADA/NORTHWEST TERRITORIES
CONSERVATION AND RENEWABLE ENERGY
DEMONSTRATION PROGRAM

MAY , 1982

FERGUSON, SIMEK, CLARK LIMITED
CONSULTING ENGINEERS & ARCHITECTS

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NORTHWEST TERRITORIES/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of N.W.T. and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed March 24, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Cost-shared by the territorial and federal governments, the program has a total budget of $3.3 million.

The objectives of CREDA are:-

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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1. SYNOPSIS

SYNOPSIS

This report describes how financial savings can be produced from mechanical modifications within an ice Arena. The savings are a result of modificaticns to the ice plant, whereby the waste heat produced by the condensers is diverted back into the Arena for space heating.

The project was initiated by the town of Pine Point and, from an energy conservation point of view, was considered worth supporting. The CREDA program, funded by the Governments of the N.W.T. and Canada, therefore contributed $45,000 to the total capital cost of $66,000. The balance of the cost was met by the town of Pine Point. The work was completed in 1981 and with space heating costs now at a minimum, a payback period of aproximately seven years is anticipated.

Ferguson, Simek, Clark Ltd. of Yellowknife, N.W.T., acted as consultants for the mechanical work, and also prepared this transfer package.

RESUME

Ce rapport discute de la manière dont l'on peut se servir pour arriver a réaliser une épargne financière en faisant des modifications mécaniques à un arena. Les épargnes sont le résultat de la modification de l'equipement de congélation pour récuperer la chaleur résiduaire produite par les condensateurs et la faire recirculer dans l'aréna pour supplémenter le système de chauffage.

Ce projet fut initié par la cité de Pine Point et au point de vue de conservation de l'énergie, nous avons cru qu'il valait la peine d'être supporté. Le programme CREDA qui reçoit ses fonds des Gouvernements des T.N.O. et du Canada a contribué $45,000 au coût total de $66,000 et la cité de Pine Point a fourni le reste. Ce travail fut complété en 1981 et du au coût réduit du chauffage il est prévu que la période de remboursement sera d'environ sept ans.

Ferguson, Simek, Clark Ltee de Yellowknife T.N.O. furent les consultants pour les travaux mécaniques et ont aussi préparé ce rapport-ci.

L'ARENA DE PINE POINT - RECUPERATION DE LA CHALEUR RESIDUAIRE DES CONDENSATEURS

INFORMATIONS GENERALLES

Pine Point est une petite ville d'environ 2000 habitants située sur la rive sud de Grand Lac des Esclaves dans les Territoires du Nord-Ouest. Son climat est nordique et a environ 8000 degrés jours en dessous de 18 degrés celsius.

L'arena local n'est pas beaucoup différent de celles que l'on retrouve dans d'autres petites villes a travers le Canada. Elle consiste d'un vestibule et de chambres d'habillage chauffées a côté d'une patinoire et de sièges de spectateurs dans une salle non-rembrissée et non-chauffée. La machinerie de réfrigération est située dans une petite cabane située tout près de l'aréna et qui originallement avait les condensateurs de refroidissement montés sur la toiture.

Durant les mois d'hiver, l'enclos des spectateurs était chauffé à moyen de chaufferettes infrarouge montées au dessus des estrades ce qui coûtait environ $10,000 par année.

MOTIVATION DU PROJET

Se basant sur le coût de l'électricité qui montait en flèche, la ville de Pine Point a pensé qu'il faudrait continuer de demander des résidents des subsides de plus en plus volumineux si l'on voulait pouvoir continuer de maintenir le même service à l'aréna. Dans un effort pour arriver a réduire le déficit, la ville a donc décidée d'essayer de récuperer la chaleur résiduelle des condensateurs et s'en servir pour réchauffer l'estrade afin de réduire l'usage des chaufferettes infrarouges.

A. Personne Contact sur la Technique du Projet:

Dana Ferguson, Ingenieur Professionel

Ferguson, Nalor, Simek, Clark Limited

B.P. 1777, Yellowknife T.N.O.

X1A 2P4

(403) 920 2882

B. Contact de la Gerance du Projet:

Secretaire-Tresorier

Cite de Pine Point

B.P. 180, Pine Point, T.N.O.

X0E 0W0

(403) 383 2800

C. Date de Finission du Projet: fevrier 1981

A. Project Technical Contact Person:

Dana Ferguson, P. Eng.
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P.O. Box 1777, Yellowknife, N.W.T.
X1A 2P4
(403) 920-2882

B. Project Management Contact:

Secretary Treasurer
Town of Pine Point
P.O. Box 180, Pine Point, N.W.T.
X0E 0W0
(403) 383-2800

C. Project Completion Date: February, 1981

2. PROJECT SUMMARY

PINE POINT ARENA - ICE PLANT HEAT RECOVERY RETROFIT

BACKGROUND

Pine Point is a small community of approximately 2,000 people, located on the south shore of Great Slave Lake in the Northwest Territories. It has a northern temperate climate of approximately 8,000 degree days below 18^{o} C.

The Community Arena is not unlike those located in numerous small towns across Canada, consisting of a heated lobby/dressing room area adjoining an unheated, uninsulated playing and spectator area. The mechanical ice plant is located in a small building near the arena, and was originally installed with the heat rejection condensers on the roof of the small building.

During the winter months, the spectator area was heated with electric infared heaters located over the bleachers at an estimated cost of $10,000 per year.

PROJECT MOTIVATION

Based on rapidly increasing electrical costs, it became apparent to the Town of Pine Point that the ever increasing operating burden would require larger and larger subsidies from the municipal taxpayers to accommodate the same level of service for the arena. In an effort to reduce that operative deficit, the Town decided to recover the rejected heat from the ice plant and use it as a source of heat for the spectators to help offset the need for electrical infared radiation traditionally used.

PROJECT DESCRIPTION

The project centered around the installation of remote condenser units in the arena with the associated refrigeration and ventilation ducting necessary to move the rejected heat to the spectator area.

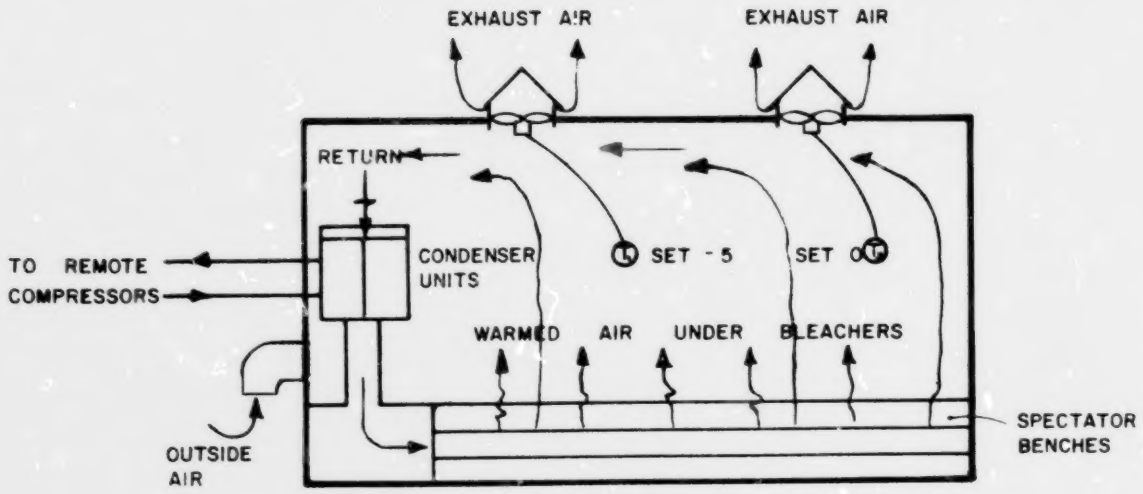
As the spectator seats were constructed of wood timber with open cracks, it was decided to pump the air under the bleachers and allow it to drift up through the cracks to warm the spectators. Volumes from the units were 18.9 m^3/sec. (40,000 CFM) total, with a total heat rejection of 244 kW maximum, discharged at an average temperature rise of 10°C during the winter. With the large crack lengths, it was anticipated that the average velocity of the air would be approximately 0.5 m /sec. (100 FPM), which would be comfortable to anyone sitting.

In order to prevent the arena from becoming too warm during spring and fall operation, it was necessary to install thermostatically controlled exhaust fans to operate in sequence when their set points were exceeded. See system schematic.

It was anticipated that in very cold weather, operation of the condensers would be too infrequent to maintain the spectator area at a reasonable temperature especially in an uninsulated building. The plan called for the infrared heaters to be cut in on a thermostat set at some value below -30°C to operate when the condenser units were off.

Typical Problems to be Addressed

Because of the nature of the ice plant, it was necessary to have the level of the condensers above that of the compressors and to have a continuous grade back to the compressor building. For this reason, the condenser units and the associated fans were mounted quite high on the end wall of the arena and to duct the air from the fans over to the bleachers for distribution. (See photo section)



SYSTEM SCHEMATIC - PINE POINT ARENA

SEQUENCE: CONDENSER UNITS CIRCULATE AIR UNDER BLEACHERS AND RETURN FROM CEILING SPACE. WHEN TEMPERATURE RISES ABOVE T1, OUTSIDE AIR DAMPER OPENS, EXHAUST FAN STARTS TO REMOVE WARM AIR. IF TEMPERATURE CONTINUES TO RISE T2 STARTS SECOND EXHAUST FAN.

SCHEMATIC I

When operation of the exhaust fans was required for cooling in spring and fall, fresh air makeup would be required. Motorized louvres were required to allow sufficient fresh air in the building to offset the exhausted volumes.

System Installation

Installation of the new remote condensers was co-ordinated and carried out under the general supervision of the Town's Department of Public Works in conjunction with input from the recreation director and the engineers.

Apart from a defective exhaust fan motor, the installation was straightforward and essentially as planned. It was originally intended to seal the area beneath the bleachers to ensure air travel along the entire length of the bleachers and upwards through the cracks. However, a closer inspection revealed that the sand beneath effectively blocked and sealed the area behind the bleachers to ensure proper migration of the air.

System Operation

The ice plant performed as designed with the installation of the remote condensers in the arena.

As anticipated, the rejected heat was passed to the recirculated building air and distributed along the entire bleacher length.

The ice plant performed normally, and detailed temperature measurements are provided in the monitoring section of this report.

As the temperatures dropped below -35° C, operation of the condensers became more infrequent and the spectator area required supplemental heat to maintain a reasonable level of comfort. By experimentation, the recreation personnel discovered that by planning the flooding just before the start of a game and by operating only one condenser, it was possible to use the latent heat of fusion in the water to warm up the bleachers for a major portion of the game, especially when flooding was carried out between periods. The conclusion reached at the termination of the monitoring period was that the planned automatic operation of the infrared heaters was unnecessary in light of "timed flooding".

Comments on the System

1. The system for this particular arena operates best at temperatures of -10° to -20°C, using the minimum condensers practical to distribute the heat over as long a period of time as possible, with fewer stop/start cycles. For those jurisdictions contemplating a similar system, it is necessary to first carry out a heat balance for the specific building and plant to obtain the optimum relation between ice making and even heating.

2. Separate exhaust fans were used in this building to control heat buildup as they were essentially in place (except for one) during the time of retrofit for condensation control. However, we would recommend that future installations make use of the main unit fans to exhaust the surplus heat via a bypass duct to the outside controlled by motorized dampers. In this manner, electricity would be saved by not running an extra set of exhaust fan motors during the spring and fall periods.

3. One side benefit of the retrofit was the reduction of hoar frost on the interior roof system with the subsequent reduction of dripping water on the ice surface. This benefit is the result of warmer roof level temperatures and lower relative humidity at that level.

4. Anyone undertaking a similar project must ensure that the spectator heat is directed locally to the spectators and then to a return located high in the arena space. This is necessary to maintain proper cold temperatures at ice level so that the ice plant does not overwork. If such were not the case, savings in infrared heat requirements may be offset by increased compressor operation.

The Financial Arithmetic

In providing this financial analysis, it should be realized that the savings are predicted on observations during monitoring as the arena has not been metered electrically in the past. As happens in the Territories, some community buildings pay on a "flat-rate basis". The building had a meter installed just before it was decided to undertake this project.

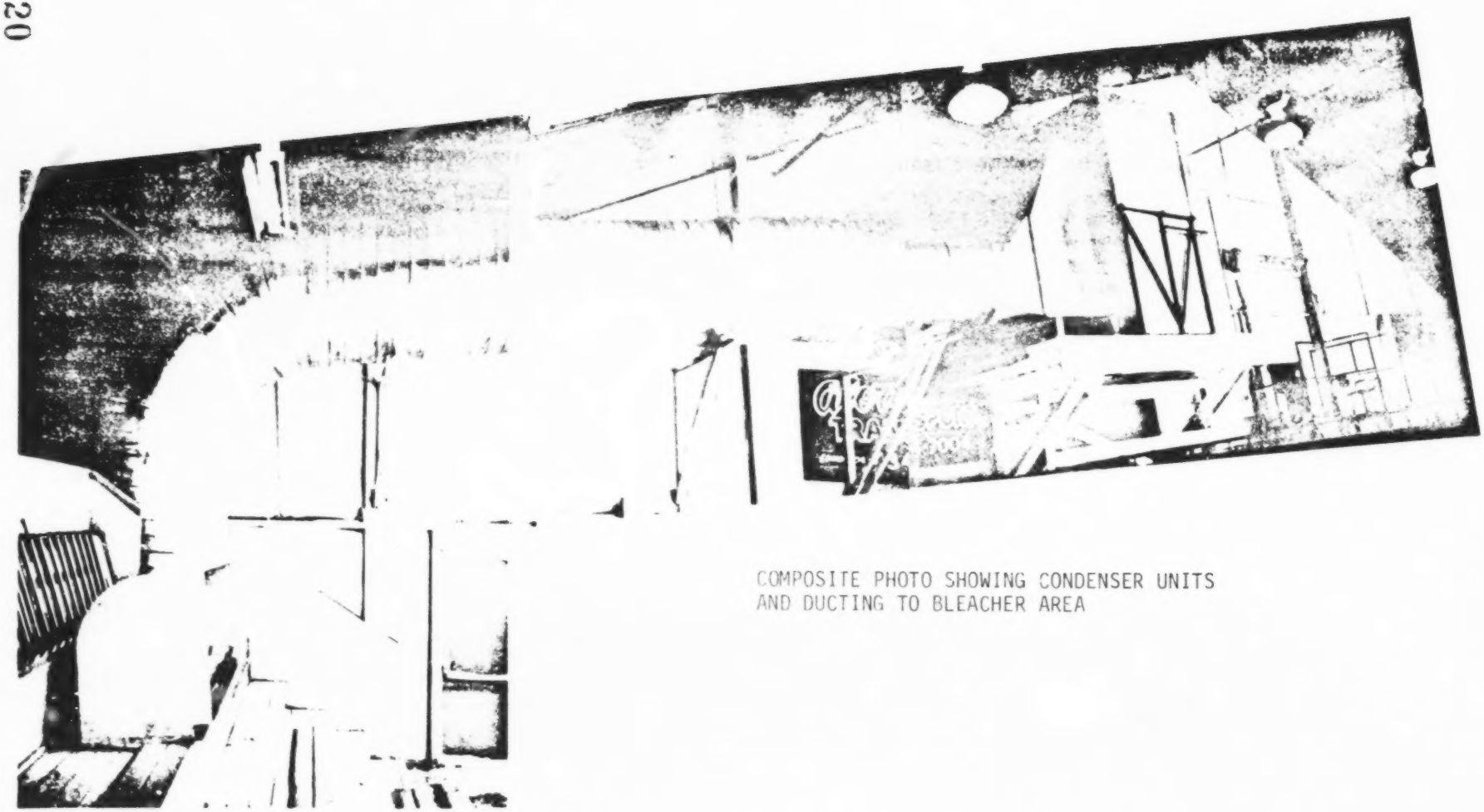
COST BREAKDOWN

1.	Materials and equipment from ice plant manufacturer.	$ 26,043.00
2.	Other Materials:	
	Lumber and miscellaneous	$ 1,162.00
	Ventilation ducting	7,235.00
	Cement	271.00
	Electrical	1,551.00
3.	Installation Labour:	
	General trades	$ 7,558.00
	Ventilation	4,200.00
	Electrical	1,150.00
4.	Engineering (Design portion only) and expenses.	$ 3,000.00
	TOTAL	$ 55,170.00

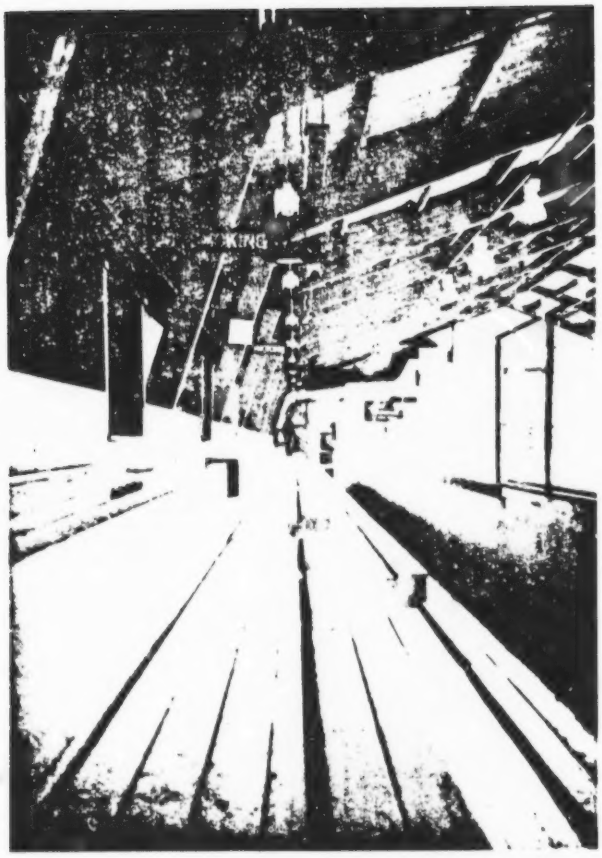
Based on the usage encountered during the past year, the predicted annual electrical savings are $ 6,500, resulting in a payout of approximately seven (8) years using a discounted rate of 11% and energy inflation rate of 15% per annum.

These savings will fluctuate with usage, giving more cost benefits with increased utilization. For a more detailed analysis, refer to the monitoring section.

3. PHOTO SECTION



COMPOSITE PHOTO SHOWING CONDENSER UNITS
AND DUCTING TO BLEACHER AREA



VIEW SHOWING BLEACHERS AND CONDENSER
DUCTING ON REAR WALL

COMPOSITE VIEW SHOWING REMOTE LIQUID AND GAS LINES INSTALLED TO ARENA CONDENSER FROM COMPRESSOR PLANT. NOTE OLD CONDENSER UNIT ON ROOF OR COMPRESSOR PLANT. FRESH AIR INTAKE IS ON LEFT OF PHOTO.

4. MONITORING AND TECHNICAL SECTION

MONITORING AND TECHNICAL SECTION

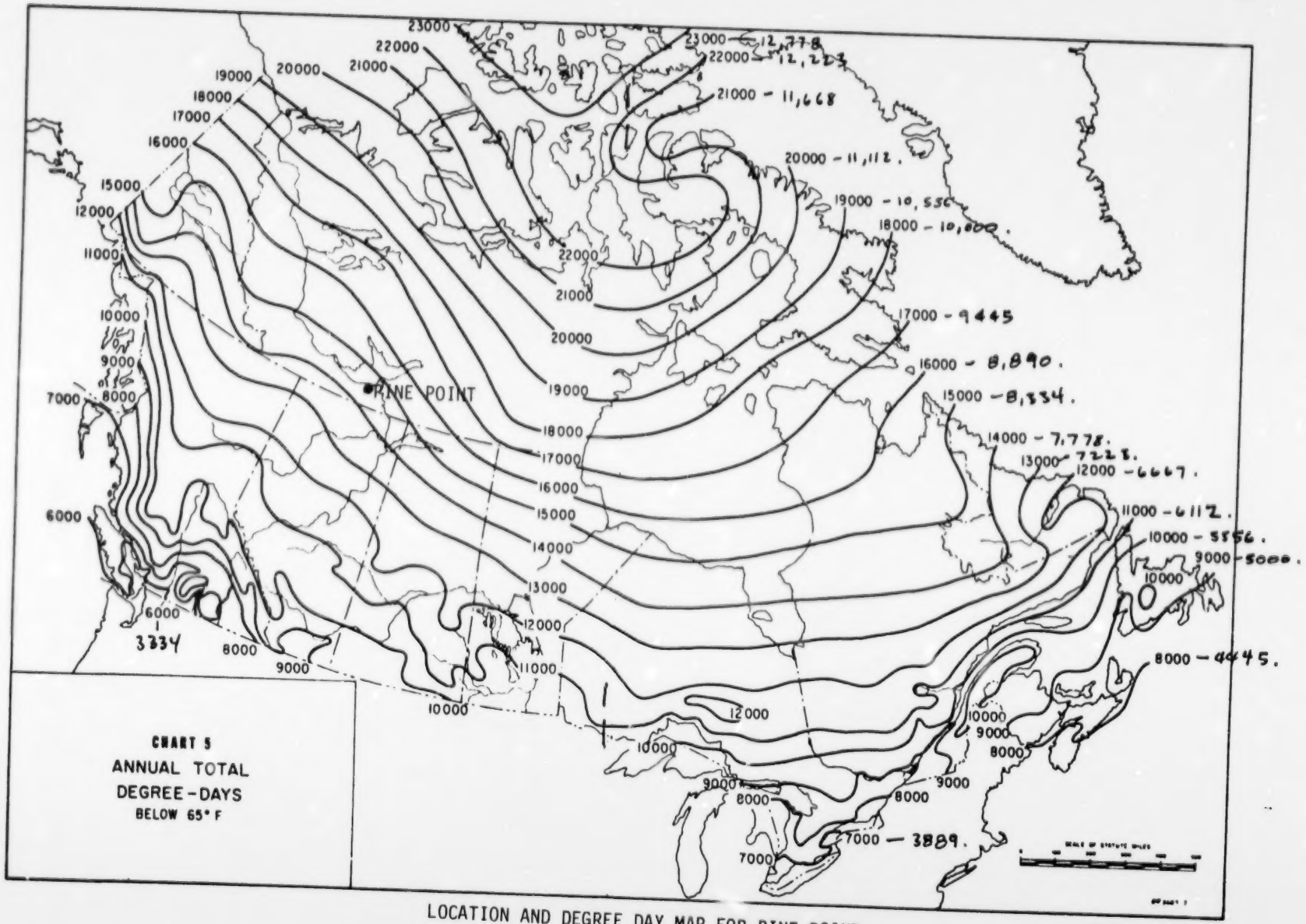
APPROACH

The approach taken during the monitoring phase was to observe the operation of the Ice Plant over an elongated time span to ensure system reliability, probable maintenance requirements, and general system performance.

Figure 1 shows that Pine Point is located in the 8,300 Degree-Day Celsius range (15,000 Degree-Day Fahrenheit) while the majority of the Canadian population is located in the 5,000 - 7,000 Degree Day Celsius environment with correspondingly less drastic mean winter temperatures. We have therefore included those test results which will be comparable to conditions encountered for the most part across the country.

MONITORING PROCEDURE

The monitoring approach included objective and subjective observation and measurement of the system during typical operating conditions. Discussions with users and technical analysis were carried out to verify the system performance over a period of approximately one year. Detailed measurements were carried out through use of calibrated probes located as shown on Figure 2. Graphs 1, 2 and 3 depict typical temperature conditions in the arena and spectator area for varying temperatures and conditions. During these tests, the condensers were manually stopped and started in order to assess the pick up and cool down rates for the arena.



LOCATION AND DEGREE DAY MAP FOR PINE POINT

FIGURE 1

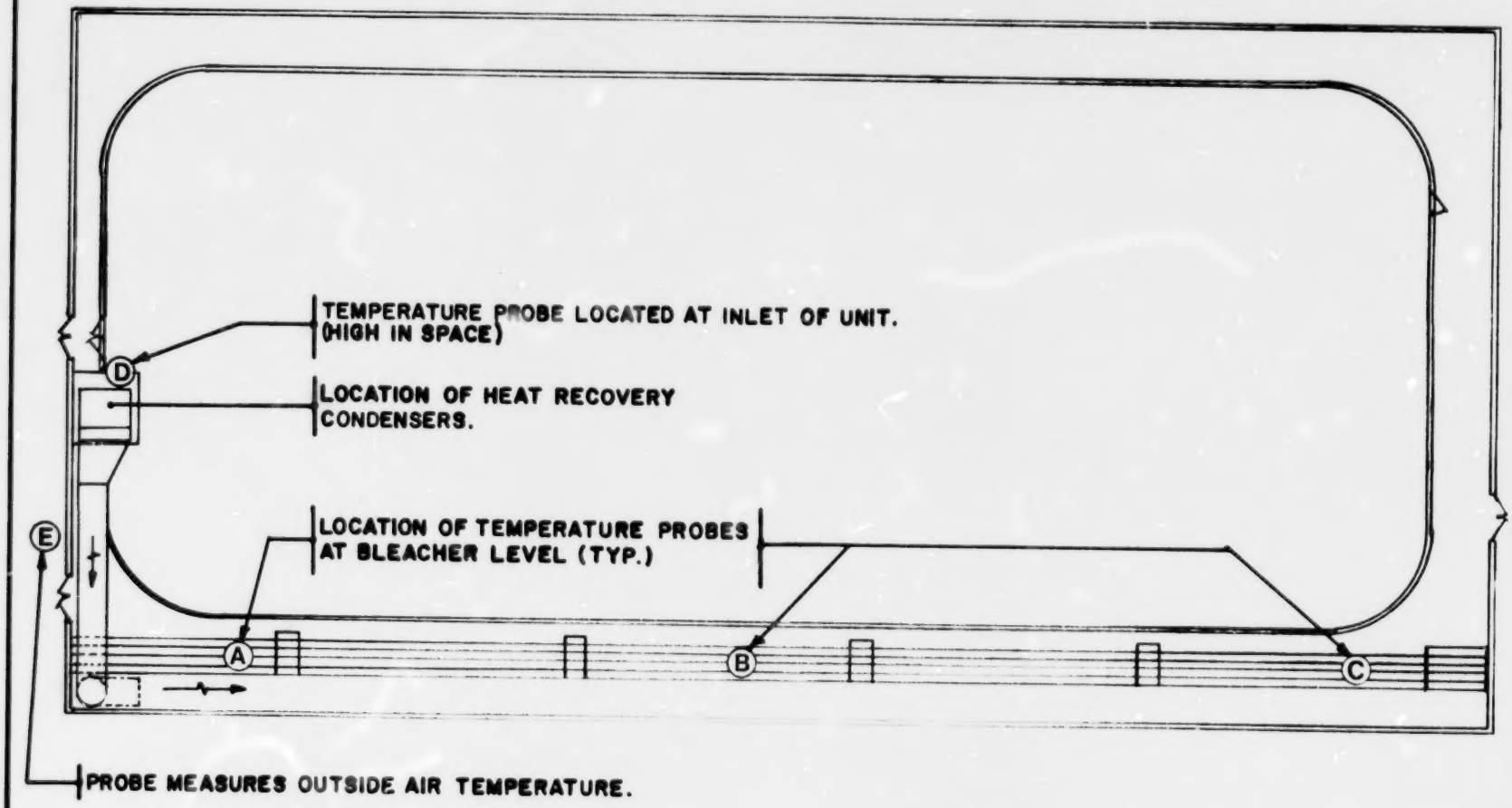


FIGURE 2

PINE POINT ARENA
HEAT RECOVERY PROJECT - LOCATION OF TEMPERATURE PROBES

A review of Graphs 1, 2 and 3 in conjuntion with Figure 2 shows that the maximum spectator temperature was obtained at the middle of the bleachers (location B) and was always slightly lower at locations A and C. The reason for this phenomenon is the result of relatively high discharge velocities from the duct under the bleachers producing high dynamic pressures but relatively low static pressures. By the time the air has travelled to position B, it has converted a greater portion of the dynamic pressure into static pressure as it expands to fill the entire area beneath the bleachers, with the bulk of the air being distributed between A and C. As the air moves from position B to C, it begins to lose total pressure due to friction losses with the result that the static pressures at C are virtually equal to the static pressures at A.

We had considered baffling the area beneath the bleachers between position A and B to increase the static pressure near the supply, however introduction of such baffles will ultimately lower the total pressure with detrimental effects occurring downstream between B and C and greatly reduced pressures at that point. In future applications, we would recommend an approach similar to the one applied in Pine Point as it provides the least energy requirement to deliver the air and still provide a statistically normalized distribution of air between A and C.

DISCUSSION

The ice plant sensor is thermally set to -7.7° C at ice level and operates through a 1° C differential. In cases where the outside temperature is lower than the ice temperature set point and there is an insignificant solar and people heat gain, the compressors and condensers will operate infrequently in steady state. In the case of Graph 1 where the outside air temperature is + 2° C, the ambient condition experienced at the bleachers will be approximately + 15° C.

Migration of the warm air from the bleachers is upwards to the inlet of the condenser units at postion D while there is not observable increase in temperature near the ice level surface during the condenser operating time. Each measurement we made to assess the influence of the increased heat distribution at the bleachers with respect to determining excess operation time for the ice plant indicated that the effect was negligible and not measurable within 1° C. In fact, it was discovered that the infrared heaters had a more detrimental influence at the ice surface by driving up the temperature in the immediate area by 2° C.

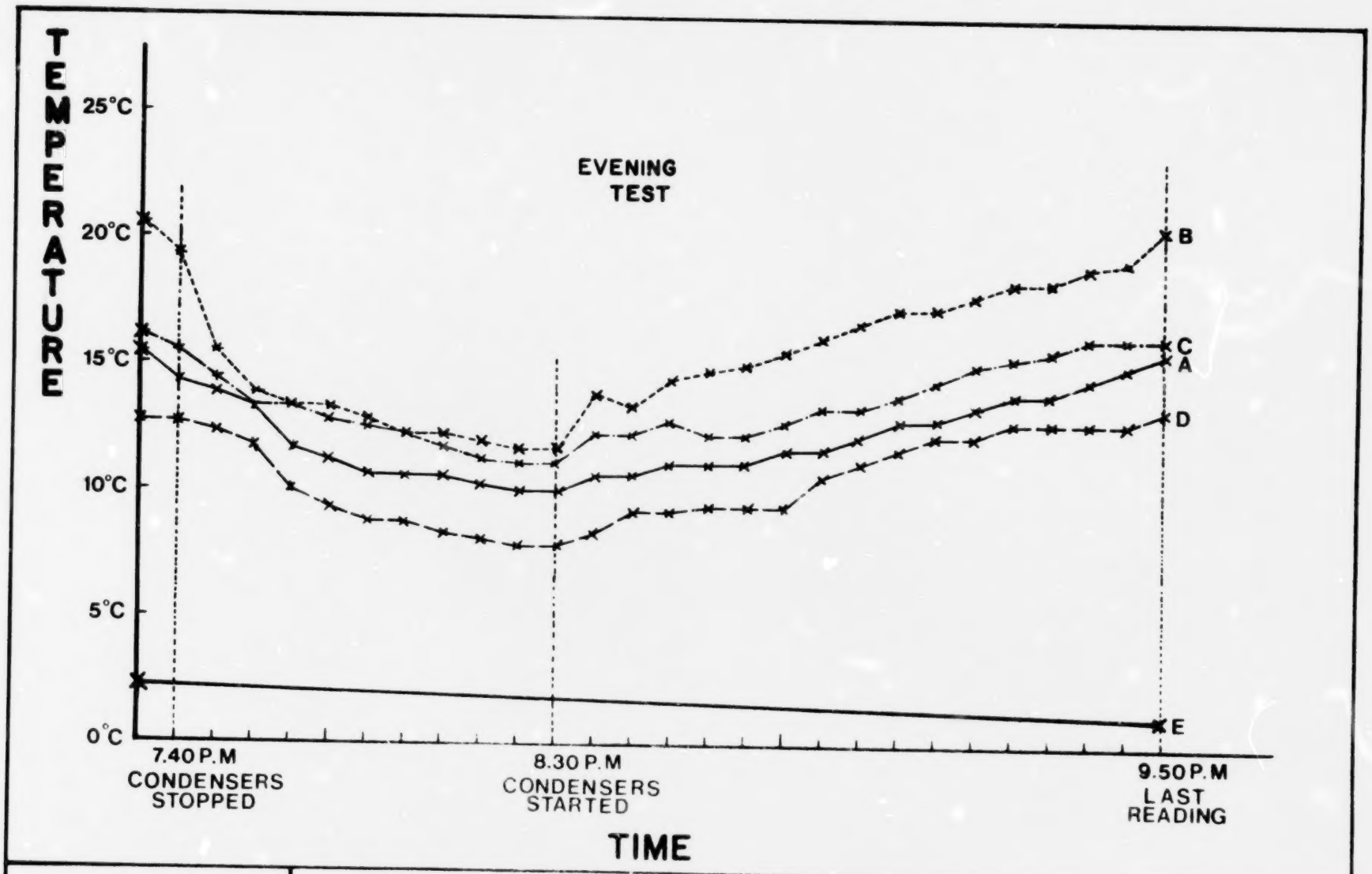
The Duty cycle in Graph 1 for the condensers proved to be about 75%.

Graph 2 shows an operating condition where heat removal from the ice is ongoing, with unit operation (not shown) at about 50% duty cycle.

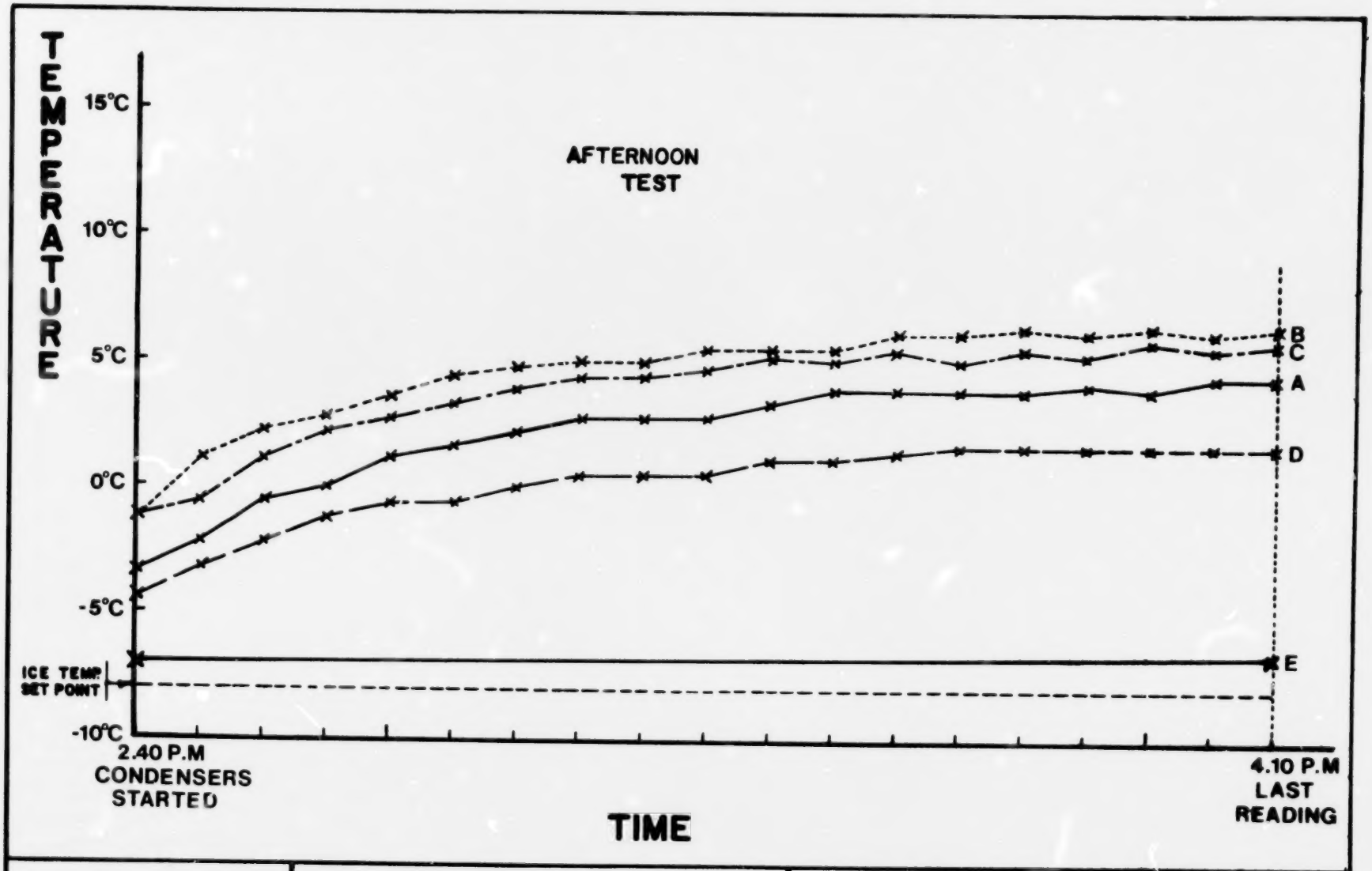
Graph 3 depicts an outside ambient temperature of approximately -17° C. In this condition, temperatures near the ice level surface are sufficiently low (within 2° C of the outside air temperature) to preclude ice plant operation in steady state. It is this condition that proves to be the most interesting, as the spectator heat is required to a greater extent as the temperature gets lower while the ice plant operational time tends towards zero. Through on-site experimentation, the arena staff developed an approach which worked sufficiently well to preclude the requirement to use the infrared heaters in any application.

By flooding the ice immediately prior to the arrival of the spectators or the start of a hockey game, it was determined that a normal flooding using approximately 900 litres of water would keep both condenser fans operating for a period of thirty minutes. By shutting down one condenser fan, the operable time could be extended to one hour with an increase in "time to useable ice after flooding" of approximately 20%. As mentioner earlier in this report, the spectator portion of the arena has no insulation so that the carry over of latent heat delivered from the water is minimal, as the building has a cool down rate of 14 Celsius degrees per hour excluding the sensible heat of the building materials. (See Graph 3)

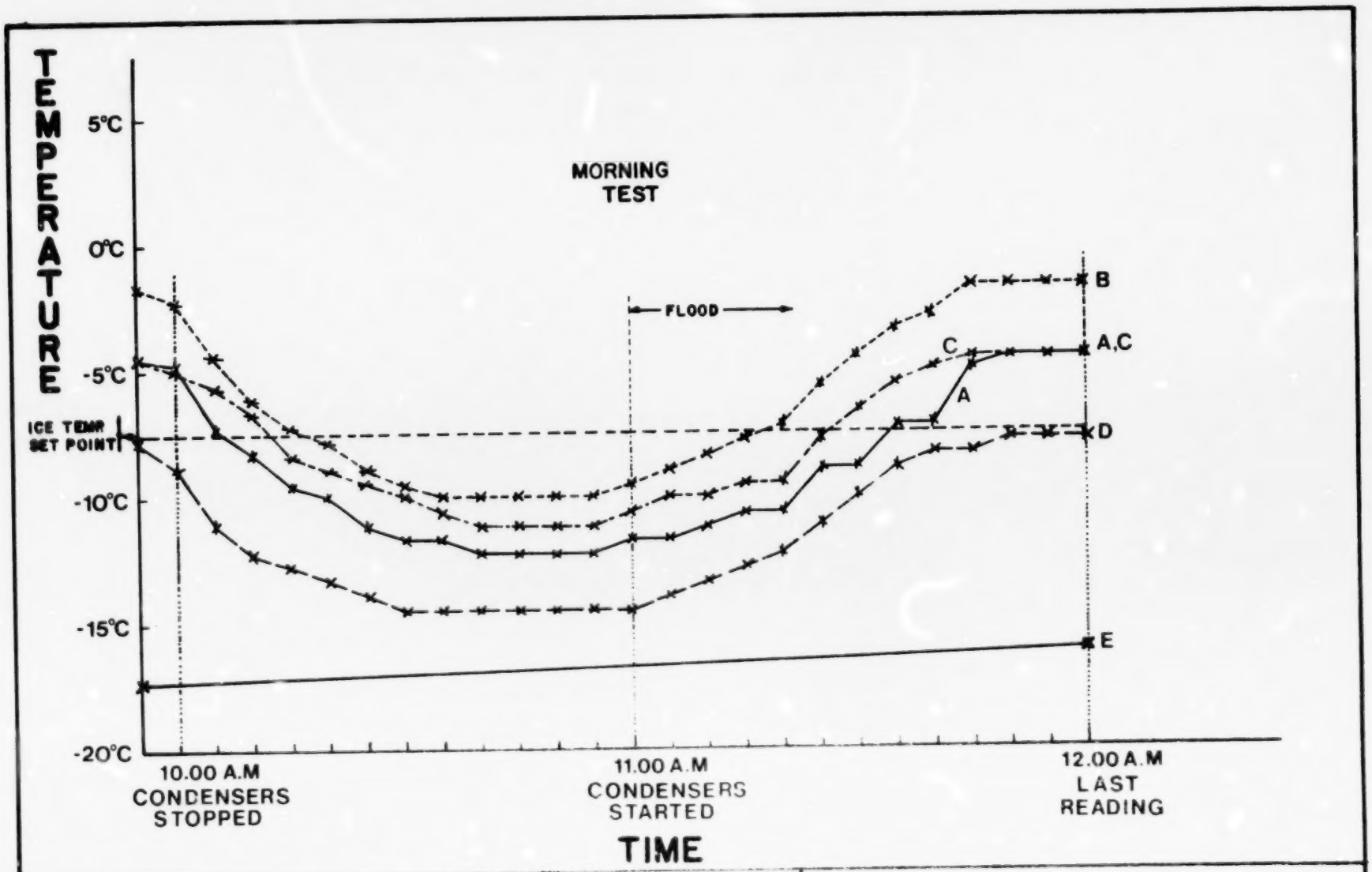
5. GRAPHS



GRAPH 1	PINE POINT ARENA HEAT RECOVERY PROJECT	TEMPERATURE VS TIME EVENING TEST



GRAPH 2	PINE POINT ARENA HEAT RECOVERY PROJECT	TEMPERATURE VS TIME AFTERNOON TEST



GRAPH 3	PINE POINT ARENA HEAT RECOVERY PROJECT	TEMPERATURE VS TIME MORNING TEST

6. SAVINGS SUMMARY

SAVINGS SUMMARY

1. Previous infrared heater operation:

KVA demand:	100 KW for the year, as assessed by power company.	
kWh used:	48,000 kWh	
Costs:	Demand charges are based on a rolling 12 month highest demand in period.	
∴	Demand costs were	
	100 kW x $4/kW/Mo. x 12 Mo. =	$ 4,800
	kWh costs =	$ 2,490
	60,000 x .0415¢ (ave)	
		$ 7,290

2. Operation as modified using ice plant waste heat.

Deletion of infrared heat	(7,290)
Addition of fan H.P. in condensers and exhaust fans to duct air vs. conventional system:	
2000 kWh x .0415	83
Increase demand charges: (3.5 kW condenser and 3.5 kW for exhaust fan)	
7 kW x 4/kW/Mo. x 12 Mo. =	$ 336
Net savings over infrared system:	$ 6,871
Possible Calculation error 5%:	$ 344
NET SAVINGS	$ 6,527

From the analysis, it can be see that the savings are dependent on total elimination of the infrared heaters to eliminate the demand penalty in the rate structure. Therefore, the modification will work best in areas where co-ordination of flooding and "liveable" minimum arena temperatures can be satisfied for the entire season without resorting to electricity for heat.

7. INFORMATION TRANSFER SUMMARY

INFORMATION TRANSFER SUMMARY

1. This project has a payout in the order of 6 to 7 years using a discount rate of 11% and energy escalation rate of 15% per annum. The savings are due to the reduced demand charges as well as reduced electrical energy usage overall.

2. The project would be unattractive for propane operated infrared heaters, placing the payout period past 10 years for heat recovery.

3. The best savings are achieved by total elimination of the infrared heater use. Therefore, climates which are extremely cold and require supplemental heat for reasons of inadequate insulation or condenser operating time are not attractive as the demand penalty for power is high, even for a single usage.

4. Successful operation of this system requires co-ordination of occupancy and flooding in relation to ambient conditions for optimum comfort.

5. Recovery of condenser waste heat has no detrimental effect on ice plant operation.

6. Waste heat recovery from arena ice plants will operate best in winter climates of - 10° C to - 20° C overall.

AUGUST, 1982

To date the following inquiries have been provided information with particular interest in waste heat recovery for municipal arenas:

1. David Thane, Arch.,
   5th Avenue and 25th Street, West,
   Saskatoon, Saskatchewan

2. David Kinnaird,
   Stanley Associates,
   10512 - 169 Street,
   Edmonton, Alberta T5P 3X6

3. Gary Marvin, Arch.,
   1006 - 11th Street, East,
   Saskatoon, Saskatchewan

4. Fred Heal,
   Director, Office of Energy Conservation,
   Regina, Saskatchewan

5. Michael Youso, Consultant,
   2500 University Drive,
   Calgary, Alberta T2N 1N4

6. G. A. Wright, P. Eng.,
   71 Water Street,
   Charlottetown, P.E.I. C1A 8L5

7. Gary Kuchinka, P. Eng.,
   30 Campus Drive,
   Saskatoon, Saskatchewan S7N 0X1

The techniques developed and applied on this project should be of value to all communities with arenas where artificial ice plants are in existence, and inexpensive heat is desired for the spectator and/or entrance and change rooms.

8. ICE PLANT DATA

TECHNICAL INFORMATION

1. ICE PLANT SPECIFICATIONS

.1 Compressor Section

Qty. 2 carrier compressors Model 5H 46
Total cooling capacity - 52 tons
Total H.P. input - 83 B.H.P.

System cooling = $52 \times \frac{12{,}000 \text{ BTU/ton}}{3410 \text{ BTU/kW}}$ = 183 kW

Work done on refrigerant
= 83 BHP x .746 kW/HP x .9 EFF.
= 56 kW

Total heat to be rejected by condensers: 239 kW

System operates as on/off - no modulation.

.2 Condenser Section

Blanchard-ness Model DDC-30-B

Fans: 10 HP
Qty. 2, each 10 M^3/sec. air volume
Total SP @ 25 mm.

Condenser sections - Qty. 2, each operated separately. One fan per condenser

Temperature rise: 10° C. Ave. across coils.

40

9. APPENDIX
MAY 1983

APPENDIX - MAY 1983

After the systems had been operating for a year we have received some feedback information from the Arena's maintenance staff. There is little doubt that all concerned are very pleased with the performance of the new system. We have been offered some recommendations and ideas for modifications in similar future installations which we shall document below.

There were two main recommendations:

1. The noise emitted from the indoor condenser is too great. The Arena is mainly used for ice hockey and figure skating and the noise has proved to be bothersome. It is therefore recommended to site the consenser outside.

2. As pointed out earlier in the report and now confirmed in practice, the exhaust fans do tend to use up unnecessary electricity.

Siting Condenser Outside

If it is intended to site a consdenser outside, then the condenser must be specified for the conditions it is to work in. Generally this does not present a problem as long as the necessary "winter start" package is included and the quality of work during installation is good. The warm air duct into the building should be insulated to avoid wasting any of the valuable heat.

The unit should be sited on a high support, suitably anchored, to protect it from the high winds and drifting snow experienced in the North.

Exhausting Hot Air to Outside

There is no reason why separate exhaust fans are required to discharge any unwanted air to outside. During the cold winter months, this warm air that builds up at high level in the Arena, should be recirculated to the spectator area. This is done by using the condenser unit fans to draw in the warm air and discharge into the bleachers, as is the case now. If the condenser unit is not at high level, a return air duct should connect the high level space to the unit.

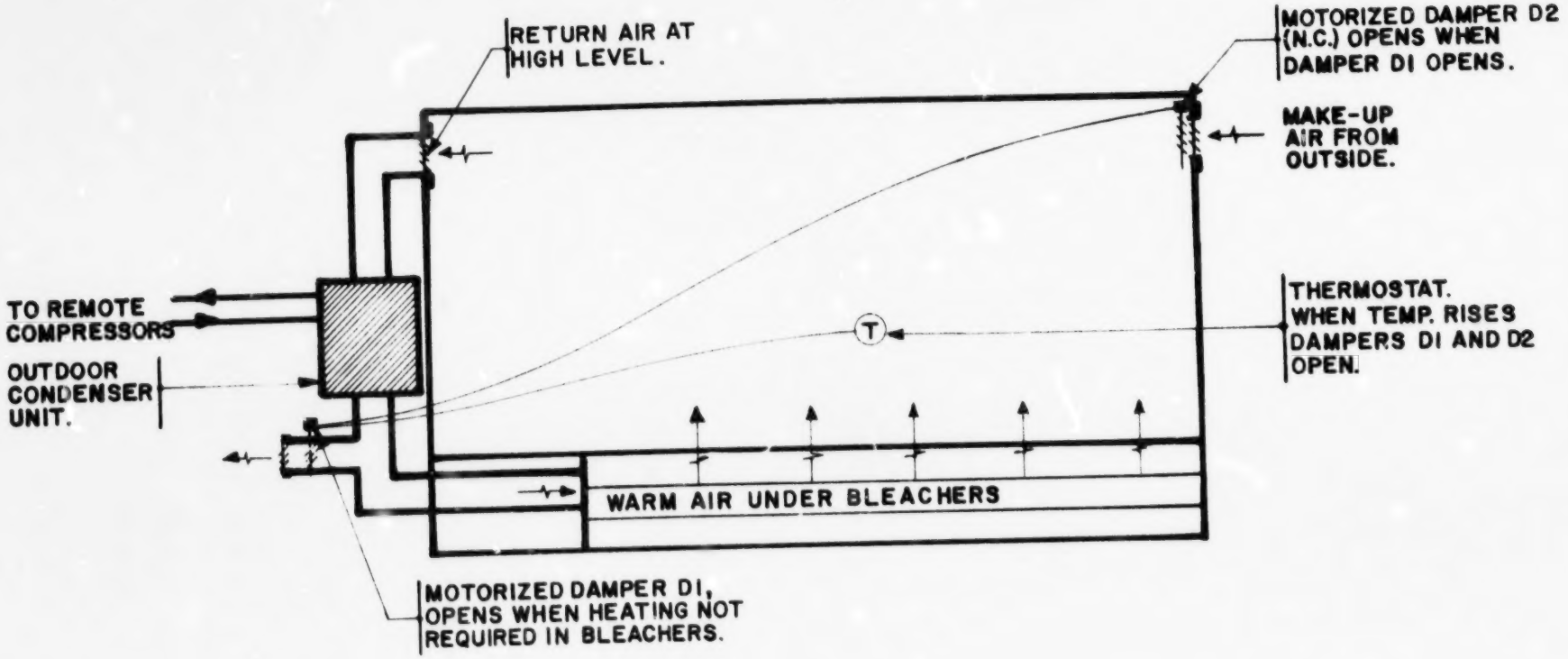
In Spring and Fall when the solar loads on the building can get high, there may be a tendency to overheat. An exhaust duct to outside, must therefore be built into the system, to discharge any unwanted hot air from the building.

Other Recommendations and Observations

In the cold weather the Zamboni is only required to flood the ice in order to keep it smooth. It is usual to use water at a temperature of approximately 55° C. The Arena staff experimented and found that if they used water at 77° C, the condenser operation is more constant and therefore the heating to the bleachers is also more constant. However there is an extra cost incurred in heating this water to the higher temperature, which should be balanced against the extra heating provided for the bleachers.

If the ice is kept as thin as possible, then this also means that the condenser must work harder, and so provide more 'waste' heat for the bleachers. There is obviously a limit to how thin the ice can be though, a minimum of 38 mm being recommended for figure skating.

It was found that with the thermostats positioned on the north wall, they were always cold and did not register the true temperature of the air at roof level. The thermostats have now been moved to high level at center ice where they are now operating more efficiently.


RETURN AIR AT HIGH LEVEL.
MOTORIZED DAMPER D2 (N.C.) OPENS WHEN DAMPER D1 OPENS.
MAKE-UP AIR FROM OUTSIDE.
TO REMOTE COMPRESSORS
OUTDOOR CONDENSER UNIT.
T
THERMOSTAT. WHEN TEMP. RISES DAMPERS D1 AND D2 OPEN.
WARM AIR UNDER BLEACHERS
MOTORIZED DAMPER D1, OPENS WHEN HEATING NOT REQUIRED IN BLEACHERS.

REVISED SYSTEM SCHEMATIC [illegible]